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SEVERAL PROBLEMS OF CONTEMPORARY SOVIET SCIENCE

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The development of contemporary Soviet science is dependent upon the special attention given to it by our government. At present there are in our country 788 institutions of higher learning, with 562,000 students. This is more than there are in the countries of Western Europe taken together. The USSR has 30 State universities, more than 100 pedagogical universities, 87 agricultural universities, 28 economics universities, and about 100 mining-technical institutions, all staffed by 50,000 professors and teachers. Moreover, we have the Academy of Sciences USSR, which includes three honorary Academies, 139 members, and 198 corresponding members. By decision of the Soviet Government, the Medical Pedagogical Academy Kazakh, and the Azerbaydzhan, Armenian, Latvian, and Estonian academies have been established.

We have created optimum conditions for work in our institutions of learning. Students are taken care of by government scholarships (up to 450 rubles a month) and free dormitories. Scientific work is assigned, literally, from the first days of a student's arrival at the university. Upon completing the institution of higher learning, the students who so desire have the opportunity of entering postgraduate work to devote their lives to science. While spending 2 or 3 years in postgraduate work, they receive government scholarships up to [illegible]00 rubles a month. Then, after finishing their courses and examinations, they have the opportunity of writing a dissertation in competition for the university degree of Candidate of Sciences (in physicomathematical science, history, chemistry etc.). After defense of their dissertations, they receive the right to work in the higher school and are given the duties of a reader. Further scientific work and creative growth of the student, after defense of a special thesis, leads to the Doctor of Science degree and the title of Professor.

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State expenditures for education are very great. The new Five-Year Plan envisaged bringing the number of 7-year elementary and intermediate schools up to 193,000, and the number of students up to 31,800,000. Compulsory intermediate training in the cities, and compulsory 7-year elementary instruction in the towns are tasks of the near future.

The president of the Academy of Sciences USSR receives a salary of 25,000 rubles a year, Academicians, 20,000; Corresponding Members, 15,000; and Professors, 6,000. Every scientist is well taken care of materially. The State provides ideal conditions for creative, scientific work.

The Soviet people and government deeply respect their scientists. By order of the Presidium of the Supreme Council USSR, 20 Academicians were named Heroes of Socialistic Labor in 1945. Each of them enriched not only the USSR's science, but also that of the world. Academician A.N. Krylov's work in shipbuilding and mathematics served to mark him a leader in World science. The names of scientists, such as Academician V.A. Komarov (deceased), former president of the Academy of Sciences, and Academicians Bogomolets, Kapitsa, Burdenko, Abrikosov, Baykov, Bardin, Bakh, Vinogradov, Zelinskiy, Lysenko, Meshchaninov, Obruchev, Orbeli, and Pryanishnikov span an entire epoch in science. In the last elections to the Supreme Soviet of the USSR, the people chose scientists as their representatives in the highest legislative body of the Soviet Union. Academician Vavilov, president of the Academy of Sciences, was chosen as a representative of the citizens of Leningrad, and Professor Ol'ga Nikolayevna was also chosen as a representative. The Ukrainian people sent Academician Bogomol'tsa, president of the Ukrainian Academy of Sciences, as their representative. Academician Denisovich Lysenko is vice-chairman of the Supreme Soviet of the RSFSR. Academician Vyshinskiy is the first deputy of the Foreign Secretary of the USSR; Academician Voznesenskiy is vice-chairman of the Council of Ministers USSR and the president of the State Planning Committee USSR; the deceased academician, Potemkin, was Minister of Education for a long while.

Participation of our scientists in the activities of the state is widespread, and is not found merely in isolated instances.

For a full picture of the conditions under which Soviet scientists work, it is necessary to tell of one more exceedingly important feature.

On the sixtieth birthday of our leader, I. V. Stalin, the Soviet Government established Stalin prizes in the amounts of 200,000, 150,000, 100,000, and 50,000 rubles for better creative work and production improvements. They are awarded by the decision of the Council of Ministers USSR. Already 1,446 men have been honored with these high prizes. But material means are not all that the Soviet people place at the disposal of their intelligentsia. They surround them with that unworldly atmosphere which is as necessary as air for free creative thought. The horizons of creative work are not contained by the walls of prejudice and obscurantism; on the contrary, they are unlimited, as unlimited as the province of the intellect. Our scientists are strangers to moods of skepticism and disbelief in the power of scientific thought, and disillusionment with the progress of science.

Now, respected gentlemen, I move to the second part of my report, which concerns the work of Soviet scientists.

The Soviet period is characterized by development of the works of topnotch scientists such as Karpinskiy, Pavlov, Vernadskiy, Kurnakov, Orbeli, Lysenko, and others. Soviet mathematicians who have attained world-wide renown are Vinogradov, Luzin, Sobolev, Bernshteyn, Muskhelishvilli and others. Exactly 200 years ago, the renowned mathematician Goldbach, in a letter to Professor Euler of the Petersburg Academy, formulated one of the most important problems in the theory of numbers. Important mathematicians throughout the world

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have looked for the solution for two centuries. Many of them have proposed that Goldbach's problem cannot be solved.

An important development in mathematics during the past years has been the work of Professor Aleksandrov, president of the Mathematical Society of Moscow. He is one of the fathers of the broad field of mathematics, topology. In his published works, he made a detailed analysis of all that has been written, and gradually, with the strict logic inherent to the outstanding mathematician, set forth the substance of topological science, developing a particular tendency called Aleksandrovskiy. This division of mathematics, concerned with the quantitative characteristics (which do not change during continuous transformations) of geometric figures, has attracted the attention of prominent mathematicians throughout the world.

The Soviet Union occupies a leading place in producing works on topology. For this place, Soviet mathematical science is obligated, to a considerable degree, to Professor Aleksandrov and the Moscow Topological School which he established.

Professor Mal'tsev found a very original method of solving a series of mathematical problems. In the past years, he had conducted an algebraic investigation on the group theory and written the following:

a. Semisimple subgroups of Lie;
b. Commutative subalgebras of the semisimple algebras of Lie;
c. The normal algebras of Lie; Theory of Groups of Lie in its entirety.

Our scientists have enriched world science by the works of such important researchers in mechanics, mathematical physics, shipbuilding theory, and ballistics as Krylov; photochemistry, biological physics, and geophysics, Lazarev; physics of crystals, photoelectricity, theory of semiconductors and insulators, Academician Ioffe; precise and important investigations in electromagnetic oscillations, waves, and physical optics, Mandel'shtam; and the optical investigations of Vavilov and Rozhdestvenskiy.

Academician Kapitsa, working with low temperatures, discovered a new, exceedingly important quality of helium, superfluidity, which is one of the most important discoveries of recent years.

A.I. Alikhanov's work on cosmic rays, is notable. An expedition will be made this year to the Alagez Mountain in Armenia to achieve greater precision in previously accumulated data on cosmic rays.

Work has been done on a new method of obtaining liquid air and liquid oxygen using a compressed gas-driven turbomotor constructed by P. L. Kapitsa to obtain low temperatures. The experimental oxygen-obtaining device, the TK-200, has the advantages of compactness, safety, simplicity of maintenance, and rapid starting.

Vavilov, president of the Academy of Sciences, investigated the phenomena of extinguishing luminescence of various solutions, and elaborated the theory of these phenomena, based upon the resonant interaction of molecules. He discovered the presence of isolated processes of protracted and transitory luminescence in organic molecules, and is credited with the discovery of a number of rules for polarized luminescence. He showed that the absolute output of luminescences of dye solutions, contrary to the existing opinion, may be considerable. Based upon representations of quantum-mechanical resonance, Vavilov devised a theory characterizing quantitively and correctly all the known phenomena of fluorescence, which made possible, according to experimental data, obtaining the value of constants that characterize the features and peculiarities in the behavior of molecules.

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Vavilov suggested a new source of cold light transforming the ultra-violet radiation which develops during the gaseous discharge in mercury vapors into visible light by insulating lamp bulbs with luminophors. These lamps are 3-4 times more economical than incandescent lamps and give an illumination close to daylight. Vavilov is the founder of a new division of physical optics -- the visual method of observing quantum fluctuations of light. He is credited with a new investigation of a special type of illumination occuring in several media during the movement in them of electrons with a speed which exceeds the capacity of light in these media.

Professor Obreimov conducted a brilliant investigation on the spectrum of absorption and the luminescence of crystals at low temperatures. Obreimov discovered a number of important regularities in these spectra, which contain the key to the understanding of many characteristics of a crystal lattice. He is credited with experiments in splitting mica and the mechanics of plastic deformation, which are unusually ingenious in simplicity and refinement.

Professor Vul discovered and investigated the unusually high dielectric permeability of barium titanate. He discovered that, under appropriate conditions, the dielectric permeability of this substance may reach values previously unheard of, 2,000 to 3,000, approximately 20 times greater than the dielectric permeability of those electric insulating materials which, hitherto, had the highest known value. Vul's discovery is of great importance to the physics of solids. In the field of high-speed radiography, a special machine has been constructed which permits momentary photographs at exposures of one millionth of a second, of processes taking place in the layers of thick metals, e.g., steel 20 millimeters thick, or light alloys up to 100 millimeters. A method for photographing such fast processes as the flight of a bullet, or explosive phenomena, has also been worked out.

New horizons in the study of nuclear physics were opened when, starting in 1932, a great many machines were invented (the most important was the cyclotron) in which the nuclei of hydrogen (protons) were accelerated to tremendous speeds with the aid of electric and magnetic poles.

The chief obstacle to the practical utilization of nuclear energy is that not one nuclear reaction is known that, having once started, can maintain itself, as does the combustion of ordinary fuel.

In 1939 a new type of nuclear reaction was discovered which had the necessary characteristics, and the situation changed radically. The scientists Hahn and Strassmann split the uranium atom into two parts by neutron bombardment releasing tremendous energy. The chief peculiarity was that the split nucleus, in its turn, released 2-3 of its neutrons. Each of them, meeting with new nuclei of uranium, cause fission, accompanied by the release of 2-3 new neutrons, etc.

Thus, each stage of the process may double or triple the number of liberated neutrons and split nuclei. Only after this regularity was established was it possible to effect the selfdeveloping or, as it is called, the chain reaction.

New, exceedingly great obstacles rose in the path of practical utilization of this discovery. Natural uranium is made up of a mixture of isotopes two of which have atomic weights of 235 and 238. U 235 is easily subjected to fission by neutrons, but in natural uranium it is contained only in 1/140 of a part. The neutrons, striking the nuclei of the isotope 238, for the most part are absorbed by these nuclei and do not split them. The following picture is obtained: the neutrons, flying from the disintegrated nucleus of the isotope 235 are attracted to the dominant isotope 238; they no longer participate in the reaction, and therefore cause no further disintegration.

The second difficulty is that a chain reaction can develop only if the piece of uranium is larger than a certain measure designated as the critical size. If the piece is smaller, then a large part of the neutrons will break away from it before the chain can begin to develop, thus making the chain reaction impossible. These difficulties have greatly complicated the process since they have precluded the possibility of working with a small amount of uranium. Since there were no assurances of success, it was necessary to start experiments on large technological scales immediately.

But as soon as the scientists were faced with the difficulties, mentioned above, ways were found to overcome them. At least two methods were contemplated. The first was very simple. It was to divide the isotopes, i.e., to separate the easily fissioned nuclei of U 235 from the 'destructive' nuclei of U 238. Practically speaking, this division is one of the most difficult experimental tasks even under laboratory conditions. Ordinary mechanical methods are unsuitable because the isotopes of both elements have the same chemical properties. Other methods for dividing isotopes, electromagnetic, diffusion, etc., are far too cumbersome and expensive.

The Americans went further. During World War II they built three plants for separating uranium isotopes in order to obtain the pure isotopes of 235. These plants are quite complex and large. We need only one example to illustrate this. U 235 was isolated from a natural mixture of both isotopes. The gaseous uranium hexafluoxide,the sole gaseous compound of the element known at that time, was evacuated from the chamber through a diaphram with an enormous number of extremely small perforations. Under these conditions, the compound of U 235 filtered through the membrane considerably faster then the U 238. After repeating this operation 4,000 times they were able to obtain the isotope 235.

It should be noted that the isotope 235 in small quantities is dangerous, but the combination of several such pieces into one piece, whose magnitude exceeds the critical size, results in a violent chain reaction and explosion. If one kilogram of uranium were to break up completely there would be as much energy given off as would be formed by the explosion of 15,000 tons of TNT. In our opinion, this method for industrial utilization of the isotope 235 is unsuitable due to the catastrophic speed of the process.

Another method has been worked out. It is based on the utilization of natural uranium without a preliminary separation of its isotopes. Under ordinary conditions, the presence of a large excess of 238 isotopes arrests the chain reaction. This difficulty is eliminated by the fact that U 238 does not absorb the slow neutrons, which split the nucleus of U 235, as efficiently as the fast ones. If, during this separation, the nascent neutrons are retarded greatly, they will bypass the nucleus of U 238 and the process will continue just as if U 238 were entirely lacking.

In connection with this, the question of moderators developed. The best one is hydrogen in the form of heavy water. However, practice has shown that the critical size increases a thousand times, up to several tons, that is to say, the U 235 in it is greatly thinned by U 238. Therefore, instead of heavy water as a moderator, graphite was used. The tests were successful. The apparatus for obtaining nuclear energy consists of piles of uranium blocks with spaces between filled with graphite. As soon as the pile reached the magnitude of the critical size, (several tons of uranium) the chain reaction began but it proceeded slowly in comparison with the process already known to us. Its speed could be regulated by the introduction of strips of metallic cadmium, which absorbs neutrons readily. With further technical elaboration, uranium piles will, to all appearances, be able to serve as a source of nuclear energy for peaceful purposes; for example, for heating boilers built into the pile.

This is a fitting time to pose a question. What takes place when the neutron is absorbed by the nucleus of U 238? It undergoes a series of very curious transformations.

A certain portion of the fast neutrons created as a result of the breakdown of the nucleus of U 235 are captured by the nuclei of U 238 before they can reach the moderating layer. In approximately 2 days U 238 becomes the nucleus of a new, earlier unknown chemical element, U 239. Then, successively, it becomes neptunium and plutonium. In the well-known periodic table of the Russian scientist Mendeleyev there are 92 elements. The last one is uranium. Plutonium, by its characteristics, should occupy the 94th place in the periodic table. It can be extracted from U 239 by chemical means. Scientists surmise that plutonium as well as pure U 235 and uranium even lighter than the latter, are subject to chain disintegration.

The production of plutonium in uranium piles was the first example, in the history of mankind, of the artificial creation of a chemical element from another chemical element. In this connection, it should be noted that only recently scientists discovered two new elements, heavier than plutonium, which may possibly turn out to be even more favorable for the chain reaction.

In substance, the problem of the utilization of nuclear energy still remains an important task. At this time it is difficult to foresee the possible paths of the future application of nuclear energy but certain aspects of the question are clear even now. Above all, there is the enormous reduction in cost of energy and augmentation energy resources. The concentration of nuclear energy will make possible its utilization in aviation, transportation and industry.

This concentration of nuclear energy will make it possible for man to obtain temperatures of hundreds of thousands of degrees. Quite obviously, with such temperatures, new ways for producing and processing various materials will arise. For example, during the splitting of one kilogram of plutonium as much energy is given off as during the combustion of 1,700 tons of gasoline. This is enough energy for a multimillion /kilometer?/ nonstop flight of the largest airplane.

Finally, it should be noted that every great scientific discovery always produced in its wake new development of theory, and following this, a new chain of discoveries. Soviet scientists are persistently working on this problem. They hope to transform nuclear energy into a powerful means of improving the lot of all workers.

The works of Scientist Zhdanov merit attention. His work on splitting the atomic nuclei produced by cosmic rays is notable. Many aspects of the phenomena of Professor Zhdanov's discovery are still puzzling but there is no doubt that a new and extremely interesting chapter in nuclear physics and cosmic rays has opened before us.

Connected with scientific works in physics and physical devices, in methodology at least, are certain scientifically interesting investigations of V. Yu. Vize, corresponding member of the Academy of Sciences. For a long time Vize worked on studies concerned with the Arctic ice cycle and toward the end of 1944 he published a scientific work entitled "Basic Long-Range Glacial Forecasts for the Arctic Seas."

In July of this year, Professor Izotov, reported on his investigations. He subjected the works of the famous German astronomer, Bessel, hitherto the basis for all geodetic and cartographical work, to a very careful examination. He found that the measurements of the earth's surface as established by Bessel were incorrect. After careful examination and use of the latest measurements of the USSR the US, and certain Western European countries Professor Izotov established that the earth's radius is 850 meters less than Bessel claimed it to be. In addition, Soviet geodesists established the fact that the earth has three axes The earth's equator is not circular but elliptical.

Soviet achievements in chemistry are famed the world over. The Academy of Sciences' chemistry staff now includes 17 academicians and 25 corresponding members.. After the October Revolution an institute of physico-chemical analysis, an institute of precious metals, high-pressure laboratories, etc, were established. In 1930 the division of chemical science was set up in the Academy. Today it has six scientific committees and publishes five theoretical journals.

Work of the young Soviet scientist Syrkin is of interest. One of the basic problems of chemical theory is the problem of the structure of chemical compounds, the nature of chemical forces. On the basis of extensive experiments and profound theoretical studies on heteropolar and homopolar bonds, Syrkin succeeded in explaining the transition from one form of bond to another and also in explaining, on this basis, many hitherto incomprehensible characteristics of chemical compounds.

Another important chemist is Zelinskiy, who first produced yperite in 1880. During World War I he suggested use of activated carbon for gas masks. Zelinskiy did work in organic catalysis, and developed a series of very important technological processes for industry.

Favorskiy is continuing the work of the great Russian chemist Butlerov. Favorskiy has contributed valuable material to the study of chemical molecular mechanics and to the development of the theory of the structure of organic compounds.

The young scientist Ya. B. Zel'dovich received the Stalin prize for work in combustion and detonation. Zel'dovich succeeded in uniting studies on the speed of ordinary chemical reactions and the theory of the diffusion of the flame and the detonation wave of an explosion.

Biology has come into its own under the Soviet regime. Zoological museums, botanical gardens, various biological institutes, all contribute not only to pure science but to practical problems in the national economy.

Pryanishnikov is the founder of USSR agricultural chemistry. He worked on phosphorite, hunted for deposits, and experimented on its application.

Lysenko's contributions to agriculture are notable: vernalization, planting potatoes in the summer, etc.

In 1945 and 1946 such important questions as physiological research on extreme nervous activity were worked on. Professor Petrov and Mariya Kapitonovna published Volume XII of "Works of the Physiological Laboratory imeni I. P. Pavlov" toward the end of 1945.

Pavlov's work in physiology is important -- nerves of the heart, physiology of glands of the digestive tract, reflexes.

In conclusion, a word about the problems on which Soviet scientists will be working:

1. Photochemistry, electrochemistry, and colloidal chemistry are gaining great significance. These have both practical and theoretical aspects.

2. We foresee considerable work on the problem of albumin and the chemical-physical bases of life processes.

3. In this era it is hardly necessary to say that atomic energy, radar, jet propulsion and telemechanics are salient problems.

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4. Our scientists are especially interested in the internal structure of matter, the problem of elementary particles, their diversity, characteristics, and interactions.

5. Our greatest scientists will work on the atomic nucleus. We believe that the crux of the most interesting theoretical problems, and probably the basis of future technics, are contained therein.

6. In the field of medicine, a large group of our scientists will work on the elaboration and study of experiences during the period of World War II. The publication, in 1948-1950, of a multivolume, capital work, "The Experience of Soviet Medicine in World War II 1941-1945" is contemplated.

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